ASSESSING INDIA'S TOTAL FACTOR PRODUCTIVITY GROWTH: DETERMINANTS, TRENDS AND CONTRIBUTION TO OUTPUT LEVELS

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Abstract

Total Factor Productivity (TFP) is defined as the fraction of output growth that is not explained by the inputs of the production function such as capital and labour. This unknown component is often attributed to technological progress. However, it can be determined by a multitude of factors that are not directly observable and thus not accounted for. This paper tries to determine those factors, particularly in the Indian context, and see which of these factors has relatively more impact on the TFP growth of India. It also tries to analyse the trends in India's TFP growth by identifying potential structural breaks. Lastly, it tries to ascertain to what extent the TFP contributes to India's output.

JEL Classification: C01, C02, D24, F43, O11, O47
Keywords: Total Factor Productivity, Technological Progress. Trends in India's TFP Growth

1. INTRODUCTION

Robert Solow laid the foundation for the concept of Total Factor Productivity. He predicted that countries would converge to their respective steady states in the long run and permanent growth will be possible only through technological progress. Solow (1957) further provided an analytical framework for calculating what is called 'Solow Residual', that is, the portion of output growth that is not explained by the inputs of the production function. This unexplained portion or residual is called Total Factor Productivity (TFP). This residual component is often attributed to technological progress which was also the case in Solow's study. However, there could be several other factors that can determine this residual component. Such factors can enhance productivity directly or indirectly by causing a technical change (Musso et al., (2005)).

The significance of TFP in determining output growth has been stressed by numerous studies of the past (See, for example, Romer (1986); Lucas (1988); Krugman (1994); Klenow and Rodriguez-Clare (1997); Hall and Jones (1999); Easterly and Levine (2001)). There has been detailed research showing evidence for advanced countries to have positive links between innovation, research and development and productivity (Griffth et al. (2004); Griffth et al. (2006); Mairesse and Mohnen (2010)). Human capital also plays a key and positive role in enhancing productivity (Romer (1990)). Bonga- Bonga and Phume (2018) found a strong and positive correlation between Foreign Direct Investment (FDI) inflows and TFP. Miller and Upadhyay (2000) have found a positive relationship between the openness of trade and TFP. In the first section of this paper, the author tries to determine the major factors that affect the TFP growth of India and see which of these factors is relatively more significant.

India's TFP growth has been fluctuating over time as it has gone through a series of wars, oil crises, political unrest and economic reforms. Throughout the 1960s and 1970s, India experienced a technical regression and the productivity growth was negative. However, the TFP growth shows noticeable change post the reforms that started in the late 1980s. The financial crisis of 2008 does not seem to have a considerable impact on India's TFP (Saha, (2012)). To understand these fluctuations in detail, the author will try to determine the trends in India's TFP

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growth in the next section of the paper. Moreover, a lot of scholars have contrasting opinions on whether TFP growth contributes as significantly to the Indian output as factor accumulation. This debate is the subject matter of the last section of the paper.

2. REVIEW OF LITERATURE

2.1 Determinants of TFP growth

There has been detailed research in this field. Griffth et al. (2006); Griffth et al. (2004); Mairesse and Mohnen (2010); and Shabbir (2016) have successfully shown that innovation in the form of patents and R&D expenditure has positive links with TFP growth. Romer (1990); Black and Lynch (1995) have shown that investment in human capital in the form of education plays a key role in improving the productivity of the economy. Miller and Upadhyay (2000) have talked about how trade can enhance productivity. Bonga- Bonga and Phume (2018) found a strong and positive correlation between FDI inflows and TFP. Jajri (2007) has stressed the role of the manufacturing sector as well as the political stability in enhancing the TFP growth of Malaysia.

2.2 Trends in TFP growth in India

Saha (2012) has examined the trends in TFP growth of India using the growth accounting methodology. This paper stressed the role of the economic reforms of 1991-92 in accelerating TFP growth in India. Veeramani (2004) and Gupta (2008) have also used the growth accounting method to stress the fact that TFP growth has been significant and rising over time. Das et al (2010) have emphasised the importance of factor accumulation in India's high growth period starting late 1980s while Bosworth et al (2007) and Gupta (2008) have highlighted the importance of productivity growth.

3. THEORETICAL FRAMEWORK

3.1 Solow Residual

The Solow residual allows us to find out the TFP growth of a country using the growth accounting method.

TFP growth = Growth Rate of Output – (Elasticity of Output with respect to capital times the growth rate of capital + Elasticity of Output with respect to Labour times the growth rate of Labour). (1)

The derivation of the result shown in equation (1) has been done in Appendix A at the end of the paper. This result shows the importance of TFP in determining output growth.

3.2 Determinants of TFP growth

Given below is a detailed description of the factors affecting TFP considered in this paper and the economic logic behind their inclusion:

a) **Growth Rate of Manufacturing Sector Output:** If an economy undergoes restructuring with a shifting of resources between sectors, and if more resources are devoted to the manufacturing sector, it can significantly enhance the productivity of the economy.

b) **FDI Inflows:** FDI in an economy, in the form of physical assets such as heavy machinery and capital, can provide for a technical change and enhance the economy's productive capacity.

c) **Innovation:** It is one of the most important factors in determining the TFP growth of a country. Innovation and R&D expenditures along with investments in technology are keys to ensuring competitiveness and progress, which in turn, ensures sustained growth. Enhancing investments in the research areas and the creation of new property rights by granting patents fosters the development of the private and public sectors and therefore, enhances the productivity of the factors of production.

d) **Education:** Human capital in the form of education, and training of the workforce to enhance their skills and widen their knowledge base, produces highly skilled and efficient workers. Manpower development has proven to be a significant means of improving the productivity of an economy.

e) **Political Stability:** Political stability is another instrumental factor in how well the inputs get utilized in the production process. An unstable government may result in several policy changes. Violence and terrorism can lead to huge economic losses. Hence, the absence of political instability and violence is also important in maintaining high TFP.

4. DATA AND METHODOLOGY

The paper has three segments. The first seeks to determine the factors that affect India's TFP growth and examine if it underwent a structural break following the global financial crisis of 2008. The second segment deals with the trends in India's TFP growth and sees at what points the TFP has undergone structural changes. The final segment of the paper tried to assess the contribution of TFP to overall output levels and compare it with the contribution of other inputs using the dominance analysis technique.

The list of all the variables used in the paper along with their interpretation has been presented in Table D.1 of Appendix D while the descriptive statistics have been presented in Table D.2. The data for TFP, CAPITAL, and LABOUR have been obtained from Penn World Table Version 9.1 available on the website of Groningen Growth and Development Centre, University of Groningen. The data for R&D, FDI, PATENT, EDUCATION, and POLITICAL have been obtained from the World Bank database. Lastly, the data for MANUFAC have been obtained from the website of 'MacroTrends.'

5. RESULTS AND DATA ANALYSIS

5.1 Determinants of India's TFP growth

5.1.1 Factors that affect India's TFP growth

To examine the relationship of the variables described in the theoretical framework, Log (TFP) will be regressed on the following variables to obtain a log-lin regression model:[1]

Model 1: $\text{Log (TFP)}_t = \beta_1 + \beta_2\text{MANUFACt} + \beta_3\text{RD}_t + \beta_4\text{PATENT}_t + \beta_5\text{FDI}_t + \beta_6\text{EDUCATION}_t + \beta_7\text{POLITICALt} + u_t$

Our econometric model is of log-lin form which will allow us to ascertain the TFP growth of India corresponding to a unit change in each of the dependent variables. The regression results are presented in Table D.3 of Appendix D.

All the partial slope coefficients are *positive* and *statistically significant.* Their interpretation goes as follows: holding other factors fixed, if we increase MANUFAC by 1 unit, then TFP grows by 0.08 per cent. Similarly, when RD, PATENT, FDI, EDUCATION, and POLITICAL grows by 1 unit, TFP grows by 0.65, 0.0003, 0.5, 0.4 and 0.2 per cent respectively, *ceteris paribus.* The results are consistent with the existing economic theory and literature. Hence, all the variables of our model are *positively related* to India's TFP growth.

The model *does not suffer* from high multicollinearity as suggested by the small values Variance Inflation Factor[2] of each of the 6 variables (see Table D.4 of Appendix D). The model does not suffer from heteroscedasticity as well, as the Breusch-Pagan[3] chi-square value comes out to be 9.93 with 6 degrees of freedom which is insignificant at 5 per cent level. The Durbin-Watson d-statistic obtained from the results was 1.8167 which rules out the presence of autocorrelation in the model as well. Lastly, the F-statistic of 451.800 and a high R-squared suggest that the model fits the data quite well. The residuals are normally distributed as the Jarque-Bera chi-square statistic so obtained was 0.07091 with 2df. Hence, at 5 per cent level, *we do reject the null hypothesis* that the residuals are normally distributed. This implies that hypothesis testing results are valid.

5.1.2 Relative Importance of the Factors Affecting India's TFP Growth

The author also tries to assess which independent variables have relatively more impact on India's TFP. To do so, the dependent, as well as the independent variables, are expressed in a *standardized* form which makes the variables unit-free and facilitates direct comparison on the basis of the estimated partial slope coefficients. Hence, the new model looks like the following:

Model 2: $\text{Log(TFP}^*)_t = \beta_1 + \beta_2\text{MANUFAC}^*_t + \beta_3\text{RD}_t^* + \beta_4\text{PATENT}_t^* + \beta_5\text{FDI}_t^* + \beta_6\text{EDUCATION}_t^* + \beta_7\text{POLITICAL}_t^* + u_t$

1 This model will use the data for the time period 1996-2017. This is the largest sample possible given the simultaneous availability of data for all the variables.

2 VIF tells the extent to which the variance of the estimators is inflated due to collinearity among the independent variables.

3 See Appendix C for a detailed description of all the statistical tests used in the paper.

The dependent, as well as the independent variables in this model, are in standardized form[4] and the stars against the names of the variables are indicative of this fact. The linear regression was run and the results are presented in Table D.5 of Appendix D.

As it is evident from the results, *the number of patent applications* has the most significant impact on TFP, followed by the manufacturing sector output growth. Therefore, in the Indian context, innovation in the form creation of new technologies and obtaining patents for them contributes most significantly to productivity growth.

5.1.3 TFP growth and the Global Financial Crisis of 2008

It was mentioned in the Introduction that research suggests that India's economy was not gravely affected by the 2008 Financial Crisis. This should allow us to hypothesize that India's TFP growth was also not severely affected by the crisis. The author looks to test this hypothesis. An attempt to examine if India's TFP growth underwent a structural break in 2008 has been made. In order to do so, a Chow test has been performed. The pooled regression (P) for the test will be Model A in section 5.1.1 for the entire time period of 1996-2017. The first restricted regression (A) will be the same model for the period 1996-2007 and the second restricted regression (B) for the period 2008-2017 (see Appendix C). The test was run and the F-statistic, so obtained, was 0.56307 which is insignificant at 5 per cent level. Thus, we do not reject the null hypothesis of no structural break. Hence, there seems to be no structural change in India's TFP growth following the global financial crisis of 2008. Hence, the results suggest that our hypothesis indeed holds true.

5.2 Trends in India's TFP growth

In this part, the author tries to examine how the TFP growth in India has performed over a period of time starting from 1960. As evident in Figure D.1 of Appendix D, the graph of log(TFP) sees sharp turns at various points which is indicative of possible structural breaks. To ascertain whether or not has India's TFP growth undergone significant changes at these points, we develop the following regression model using dummy variables:

Model 3: $\text{Log(TFP)}_t = \beta_1 + \beta_2 t + \beta_3 D_{2t} + \beta_4 D3t + \beta_5 D_{4t} + \beta_6 D_{5t} + \beta_7 D_{6t} + \beta_8 D2t.t + \beta_9 D_{3t}.t + \beta_{10} D_{4t}.t + \beta_{11} D_{5t}.t + \beta_{12} D_{6t}.t + e_t$

The points examined for breaks are 1966, 1976, 1992, 2007, and 2009 as suggested by the graph. Thus, the definition of the dummies goes as follows:

When, $D_{2t} = D_{3t} = D_{4t} = D_{5t} = D_{6t} = 0$, the time period is 1960-1965;[5]

D_{2t} = 1 (1966-1975)
= 0 (otherwise);
D_{3t} = 1 (1976-1991)
= 0 (otherwise);
D_{4t} = 1 (1992-2006)
= 0 (otherwise);
D_{5t} = 1 (2007-2008)
= 0 (otherwise);
D_{6t} = 1 (2009-2017)
= 0 (otherwise)

The regression results are presented in Table D.6 of Appendix D and the estimated equations for each period separately are presented in Table D.7 of Appendix D.

It is evident from the results that the coefficient of D_{2t} is statistically significant at 10 per cent level while the coefficients of D_{3t} and D_{4t} are significant at 5 per cent level and 1 per cent level respectively. This implies that the average value of log(TFP) is significantly different in periods 1966-1975, 1976-1992, and 1992-2006 from the reference period of 1960-1965. So, only the points 1966, 1976 and 1992 cause a structural change in the level of TFP. As far as the growth rate is concerned, only the coefficient of $D_{4t}.t$ is statistically significant (significant at 10 per cent level). This implies that the growth rate of TFP during 1992-2006 is significantly different from the growth rate[6] during 1960-1965. The compounded growth rate during 1992-2006 is 0.76 per cent while the compounded growth rate during 1960-1965 is much lesser (0.39 per cent). This is a strong conclusion as it reaffirms the fact that the landmark

[4] See Appendix B for understanding the logic behind standardization.

[5] This time period is the reference category, the benchmark against which the comparisons are made.

[6] Compounded Annual Growth Rate = antilog (b2) – 1. The author has taken compounded rather than instantaneous rate of growth because we are concerned with growth over a period of time and not at a point of time.

reforms of 1991-92 had a positive and significant effect on the Indian economy's performance. Additionally, it must be noted that the growth rate of TFP during 2007-2009 is not statistically different from the reference category which suggests that India did not suffer much during the 2008 Financial Crisis, not at least in terms of TFP growth. This is consistent with the result obtained in section 5.1.3.

5.3 Contribution of TFP to India's Output

In this final segment, the author tries to compare the contribution of TFP to India's output over the years relative to the other factors of the production function – labour and capital. In order to do so, the technique of dominance analysis has been used. Dominance analysis is a method that helps to ascertain the contribution of each of the independent variables to the dependent variables. This exercise involves calculating the additional contribution of each independent variable to each subset model that is measured by the increase in R-squared value that results from adding that variable to the original subset model.

Bodescu (1993) explains dominance by stating that the independent variable X^{3i} dominates X^{2i} when X^{3i} is chosen over X^{2i} in all possible subsets of models where only one of these two variables is to be entered.

Consider the following regression model:

Model 4: $OUTPUT_t = \beta_1 + \beta_2 TFP_t + \beta_3 CAPITAL_t + \beta_4 LABOUR_t + u_t$

We are trying to assess whether the contribution of factor productivity was as significant as factor accumulation to India's output. We use the R-squared metric to do this analysis. First, we regress only TFP on output and obtain an R-squared value of 0.765, and when we add CAPITAL to the model and regress it along with TFP on OUTPUT, we get an R-squared of 0.981. The difference between the two values which is 0.216 is what we call the additional contribution of CAPITAL. We repeat this exercise for CAPITAL and LABOUR by regressing them individually on OUTPUT and finding out the additional contribution of the other variables. The average of all these contributions gives us the average contribution of each of the three variables at Level 1. At Level 2, we first regress any two variables on OUTPUT and then try to assess the additional contribution of the third variable. For example, if we regress only TFP and CAPITAL on OUTPUT, we get an R-squared value of 0.981. But if we also include LABOUR in the model and regress all three on OUTPUT, we get an R-squared value of 0.993. So the difference of 0.012 (0.993-0.981) gives us the additional contribution of LABOUR. Averages of these contributions give us the averages for Level 2. At Level 3, all the three variables are regressed on OUTPUT. Naturally, the additional contributions will be zero as there are only three variables in the model. See Table D.9 in Appendix D for the complete matrix.

The final contributions come out as follows: TFP: 0.287, CAPITAL: 0.451, LABOUR: 0.255. TFP's contribution is just greater than that of LABOUR which reaffirms the fact that factor productivity contributes as significantly to output as factor accumulation, at least in the Indian context. It also emphasizes the need to focus on factors that can enhance TFP, such as those discussed above, besides those affecting labor and capital in order to achieve higher output levels.

6. CONCLUSION

Total Factor Productivity (TFP) is defined as the fraction of output growth that is not explained by the inputs of the aggregate production function. TFP growth plays a key role in overall economic growth and there could be a series of factors that can affect it. Along these lines, the first objective of this paper was to determine the factors that affect India's TFP growth. After an extensive review of the literature and examining the economic theory, the author tried to determine the relationship of TFP with six key factors: Growth rate of manufacturing output, R&D expenditure (as % of GDP), number of patent applications by residents and non-residents, FDI inflows (as % of GDP), expenditure on education (as % of total government expenditure), and political stability. Log(TFP) was regressed on these six variables and the results suggested that there exists a strong and positive relationship between TFP growth and each of the six variables. The next objective was to see which of these six factors affects the TFP growth the most. To do so, standardized regression was run and it was found that the number of patent applications has relatively the most significant on

TFP growth in India.

The next objective of the paper was to discuss if the TFP growth of India underwent a structural break during 2008. A Chow test was run to determine this and it was found that India's TFP growth did not undergo a structural break during 2008. The next section of the paper examined trends in India's TFP growth and test for structural changes during the period 1960-2017. Based on graphical analysis, the points- 1966, 1976, 1992, 2007, 2009 were chosen to test for structural changes and a dummy variable model was used. It was found that the structural breaks in the level of TFP were observed in 1966, 1976, and 1992. It was also found that the growth rate of TFP during 1992-2006 was much higher than the reference period of 1960-1965 which stressed the positive impact of the 1991-92 structural reforms on the Indian economy.

The final section of the paper looked to determine if the contribution of TFP to India's output relative to the other two factors (labour and capital) was significant or not. Dominance technique was used to ascertain this and it was found that the factor productivity's contribution to output levels was as high as the main inputs, that is, labour and capital.

APPENDIX

Appendix A: Appendix A: Understanding TFP growth using the growth accounting equation

Consider the following production function:

$$q = A(t)f(K,L) \quad (2)$$

Here, A is generally conceded to be the technical progress parameter but in a broader sense, it's the parameter capturing the factors not captured by the inputs of the production function.

Differentiating both sides of equation (2) w.r.t time (t)

$$\frac{dq}{dt} = \frac{dA}{dt} f(K,L) + A(t)\frac{df(K,L)}{dt} \qquad (3)$$

$f(K,L)$ can be written as $\frac{q}{A(t)}$ and $A(t)$ can be written as $\frac{q}{f(K,L)}$ (from equation (2)). Substituting these values in equation (3), we get:

$$\frac{dq}{dt} = \frac{dA(t)}{dt}.\frac{q}{A(t)} + \frac{q}{f(K,L)}.\frac{df(K,L)}{dt}$$

Total differentiating $f(K,L)$ on the right-hand side, we get:

$$\frac{dq}{dt} = \frac{dA(t)}{dt}.\frac{q}{A(t)} + \frac{q}{f(K,L)}\left(\frac{df(K,L)}{dK}.\frac{dK}{dt} + \frac{df(K,L)}{dL}.\frac{dL}{dt}\right)$$

Dividing both sides by q

$$\frac{1}{q}\frac{dq}{dt} = \frac{dA}{dt}\frac{1}{A} + \frac{1}{f(K,L)}\left(\frac{df(K,L)}{dK}.\frac{dK}{dt} + \frac{df(K,L)}{dL}.\frac{dL}{dt}\right)$$

Doing some manipulation, we get:

$$\frac{1}{q}\frac{dq}{dt} = \frac{dA}{dt}\frac{1}{A} + \frac{df(K,L)}{dK}\frac{K}{f(K,L)}.\frac{1}{K}\frac{dK}{dt} + \frac{df(K,L)}{dL}.\frac{L}{f(K,L)}.\frac{1}{L}\frac{dL}{dt}$$

Using the definitions of growth rates and elasticity, we get:

$$G_q = G_A + EI_{q,K}.G_k + EI_{q,L}.G_L$$

$$G_A = G_q - (EI_{q,K}.G_k + EI_{q,L}.G_L)$$

$$\text{TFP growth} = G_q - (EI_{q,K}.G_k + EI_{q,L}.G_L) \quad (4)$$

Hence, equation (4) gives us the mathematical derivation of TFP growth.

Appendix B: Understanding Standardised Regression

Consider a simple linear regression model:
$Y_t = \beta_1 + \beta_2 X_t + e_t$

Then the standardised variables Y* and X* are defined as follows:

$$Y^* = \frac{Y - Y_m}{SD_Y}$$

And

$$X^* = \frac{X - X_m}{SD_X}$$

Where Y and X are means of Y and X respectively while SD and SD are the standard deviations of Y and X respectively. This standardisation process makes the variables unit-free which allows us to directly compare the relative impact of each of the independent variables on the dependent variables. After the estimation of the model, the intercept is approximately zero.

Appendix C: Statistical Tests used

1. Breusch-Pagan test for heteroscedasticity
H_0: Error variance is homoscedastic.
H_1: Error variance is not homoscedastic.
BP statistic = $nR^2 \sim Chi - square_{No.of\ regressors}$

2. Jarque-Bera test of normality of residuals
H_0: Residuals are normally distributed
H_1: Residuals are not distributed

$$JB = \frac{n}{6}(S^2 + \frac{1}{4}(K-3)^2)$$

3. Durbin-Watson d-statistic test for auto-correlation

$$d = \frac{\sum_{t=2}^{t=n}(e_t - e_{t-1})^2}{\sum_{t=1}^{t=n} e_t^2}$$

If $d_L < d < d_U$, then, there is no evidence of positive or negative autocorrelation.

4. Chow test for structural change

Regression 1 (pooled): $Y = A_1 + A_2X_1 + \ldots\ldots\ldots\ldots\ldots + A_{n+1}X_n$

Regression A: $a_1 + a_2X_1 + \ldots\ldots\ldots\ldots\ldots + a_{n+1}X_n$

Regression B: $b_1 + b_2X_1 + \ldots\ldots\ldots\ldots\ldots + b_{n+1}X_n$

H_0: No structural change ($a_1 = b_1$, $a_2 = b_2$, and so on)

H_1: Structural change observed ($a_1 \neq b_1$, $a_2 \neq b_2$, and so on)

The corresponding F-statistic equation for the test is:

$$F = \frac{(RSS_p - RSS_A - RSS_B)/k}{RSS_A + RSS_B/(n-2k)}$$

Appendix D: List of Tables and Charts

D. 1 List of variables used in the paper

Variable Name	Interpretation
TFP	Natural logarithm of Indian's Total Factor Productivity
MANUFAC	Growth Rate of India's Manufacturing Output
RD	Expenditure Incurred By India on Research and Development (as % of GDP)
PATENT	Patent Applications Filled by Resident and Non-Resident Indians.
FDI	Foreign Direct Investment Net Inflows (as % of GDP)
EDUCATION	Government Spending on Education (as % of total government expenditure)
POLITICAL	Estimate of governance in terms of Political Stability and Absence of Terrorism/Violence (ranges from approximately -2.5 (weak) to 2.5 (strong) governance performance)
CAPITAL	Capital stock at constant 2011 national prices (in mil. 2011US$)
LABOUR	Number of persons engaged in Employment (in millions)

D. 2 Descriptive statistics of the variables

	log (TFP)	MANUFAC	RD	PATENT	FDI	EDUCATION	POLITICAL	LABOUR	CAPITAL
Interpretation	-0.42177	8.954090	0.7409	27363.09	1.447272	13.3692761	-1.109	346.866488	6429660.12
Mean	0.011318	1.943837	0.0124	3311.09	0.168230	0.3514	0.0396	14.6167833	1093416.85
Standard Error	-0.402	7.2575	0.731	31607.5	1.41	13.366	-1.0856	346.045456	2030588.63
Median	0.053087	9.117405	0.0584	15530.39	0.789071	1.6482	0.1857	N/A	N/A
Standard Deviation	0.002818	83.12707	0.0034	2411931	0.622633	2.7167	0.0345	113.221117	8469570.49
Sample Variance	-1.80655	-0.83224	-0.5654	-1.80460	1.127247	-0.002	-0.5495	12819.0213	7.1734E+13
Kurtosis	-0.19357	0.484782	0.3640	-0.1573	0.997401	0.6022	-0.2475	-1.2130256	2.58187548
Skewness	0.141	29.704	0.22	41756	3.148	5.7686	0.7440	0.00498377	1.90034321
Range	-0.491	-3.584	0.639	4826	0.473	11.191	-1.5087	427.044623	32586619.1
Minimum	-0.35	26.12	0.859	46582	3.621	16.959	-0.7646	110.790277	798800.875
Maximum	-9.279	196.99	16.3	601988	31.84	294.12	-24.403	537.8349	33385420
Sum	22	22	22	22	22	22	22	20811.9893	385779607
Count	-0.42177	8.95409	0.740	27363.09	1.447272	13.369	-1.109	60	60

D. 3 Regression results of Model 1

	Coefficients	Standard Error	t Stat
Intercept	-0.5966978	0.0261732	-22.7980412
MANUFAC	0.0008094	0.0001539	5.259242****
R&D	0.00650058	0.0343533	1.8922696*
PATENT	0.0000031	0.0000001	21.81264****
FDI	0.0050356	0.0027293	1.8449798*
EDUCATION	0.0040474	0.0009716	4.165700****
POLITICAL	0.0246452	0.0116506	2.1153637*

****: Significant at 0.01%, ***: Significant at 0.1% level, **: Significant at 5% level and *: Significant at 10% level

R-squared: 99.4%
Standard Error of Regression: 0.004
F-statistic: 451.800

D. 4 Variance Inflation Factors for Model 1

Variable	Variance Inflation Factor
MANUFAC	1.90
RD	3.89
PATENT	4.78
FDI	4.48
EDUCATION	2.48
POLITICAL	4.52

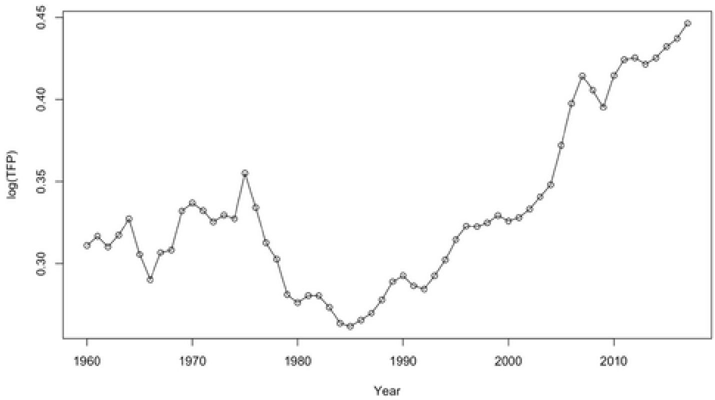
D. 5 Regression results of Model 2

	Coefficients	Standard Error	t Stat
Intercept	-0.5966978	0.0261732	-22.7980412
MANUFAC	0.0008094	0.0001539	5.259242****
R&D	0.00650058	0.0343533	1.8922696*
PATENT	0.0000031	0.0000001	21.81264****
FDI	0.0050356	0.0027293	1.8449798*
EDUCATION	0.0040474	0.0009716	4.165700****
POLITICAL	0.0246452	0.0116506	2.1153637*

****: Significant at 0.01%, ***: Significant at 0.1% level, **: Significant at 5% level and *: Significant at 10% level

R squared = 99.4%
Standard Error of Regression = 0.089
F-statistic = 451.800

Figure D. 1 Trends in TFP growth in India



D. 6 Regression results for model 3

	Coefficients	Standard Error	t Stat
Intercept	-0.5035244	0.01862666	-27.032457
Time	0.00039431	0.00478289	0.08244231
D2i	-0.0545085	0.03462319	-1.5743341*
D3i	0.0648197	0.03058877	2.11906854**
D4i	-0.2868322	0.05158721	-5.5601422***
D5i	0.56601317	1.37255192	0.41238015
D6i	-0.1355294	0.14088102	-0.9620133
D2i.t	0.00543281	0.00543582	0.99944598
D3i.t	-0.0046733	0.00488438	-0.956776
D4i.t	0.00726709	0.00493009	1.47402922*
D5i.t	-0.0096682	0.02869731	-0.3369015
D6i.t	0.0045468	0.00543582	0.83645065

****: Significant at 0.01%, ***: Significant at 0.1% level, **: Significant at 5 % level and *: Significant at 10 % level

R squared = 92.19%
Standard error of regression = 0.02
F statistic = 49.37

D.7 Period-wise estimated equations for Model 3

Time Period	Dummy Variable criteria	Estimated equation
1960-1965	$D_{2t} = D_{3t} = D_{4t} = D_{5t} = D_{6t} = 0$	Log(TFP) = -0.503 +0.0039t
1966-1975	$D_{2t} = 1$ (1966-1975) = 0 (otherwise);	Log(TFP) = -0.041 +0.0058t
1976-1991	$D_{3t} = 1$ (1976-1991) = 0 (otherwise);	Log(TFP) = -0.438-0.0042t
1992-2006	$D_{4t} = 1$ (1992-2006) = 0 (otherwise);	Log(TFP) = -0.7903+0.0076t
2007-2008	$D_{5t} = 1$ (2007-2008) = 0 (otherwise);	Log(TFP) = 0.0624-0.0092t
2009-2017	$D_{6t} = 1$ (2009-2017) = 0 (otherwise)	Log(TFP) = -0.639+0.00049t

D. 8 Regression results of Model 4

	Coefficients	Standard Error	t Stat
Intercept	1.2429E-16	0.01122152	1.1076E-14
TFP*	0.00812935	0.02442384	0.3328447
CAPITAL*	0.85158042	0.02876218	29.6076415
LABOUR*	0.17161891	0.01770864	9.69125494

D. 9 Dominance Analysis

Model	R-squared	Additional Contribution		
		TFP	CAPITAL	LABOUR
Subset Model 1 (Only one independent variable is regressed)				
OUTPUT= TFP + ui	0.765	-	0.216	0.116
OUTPUT= CAPITAL + ui	0.981	0.000	-	0.012
OUTPUT= LABOUR + ui	0.690	0.191	0.304	-
AVERAGE FOR LEVEL 1	-	**0.096**	**0.26**	**0.064**
Subset Model 2 (Only two independent variables are regressed)				
OUTPUT= TFP + CAPITAL + ui	0.981	-	-	0.012
OUTPUT= TFP + LABOUR + ui	0.881	-	0.112	-
OUTPUT= CAPITAL + LABOUR + ui	0.993	0.000	-	-
AVERAGE FOR LEVEL 3	-	**0.000**	**0.112**	**0.012**
Subset Model 2 (All three independent variables are regressed)				
OUTPUT = TFP + CAPITAL + LABOUR + ui	0.993	-	-	-
OVERALL AVERAGE CONTRIBUTION (LEVEL 1+ LEVEL2)	-	**0.287**	**0.451**	**0.255**

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